Flight Patterns of some Eastern Australian Bats

By P. D. Dwyer*

Introduction

A knowledge of specific flight patterns in bats may throw light upon feeding specializations and, in this way, provide some insight into the ecological diversity shown by the species found in a particular area. In addition, this information can provide useful clues for field identification. With these aims in mind certain morphological flight attributes were measured for most of the microchiropteran species known from New South Wales and Victoria. The megachiropteran, *Pteropus scapulatus,* has been included for comparison. Where possible, correlation between deduced flight pattern and behaviour in the field or laboratory has been recorded. The field observations were made in north-eastern New South Wales.

Nomenclature used in this report is based on the recommendations of Tate (1952 and references therein), with the exception that the molossid species is named *Tadarida* rather than *Nyctinomus* (see Hill, 1961).

Methods

The morphological criteria used here are aspect ratio (with and without uropatagium), wing loading, uropatagial loading, and the ratio wing area/uropatagial area. Aspect ratio is taken as span^2/area where span is from wing tip to wing tip and area is of the relevant membranes only. Load is in pounds/sq. ft. of wing area. By analogy with birds and other bats, short broad wings (low aspect ratio) are considered to suggest slower and more manoeuverable flight than long narrow wings (high aspect ratio). Struhsaker (1961) and Vaughan (1959) have demonstrated this for several North American bats. In addition high aspect ratio may be considered an indication of sustained flight and high speed. Similarly, low and high loading may be accepted as indicative of increased or decreased manoeuverability (Vaughan, *loc. cit.*). The uropatagium is probably significant in lift, braking, and turning, and consequently low values for the ratio wing area/uropatagial area may again suggest increased manoeuverability. Thus for all the morphological criteria used here high manoeuverability may be expected from low values, and vice versa.

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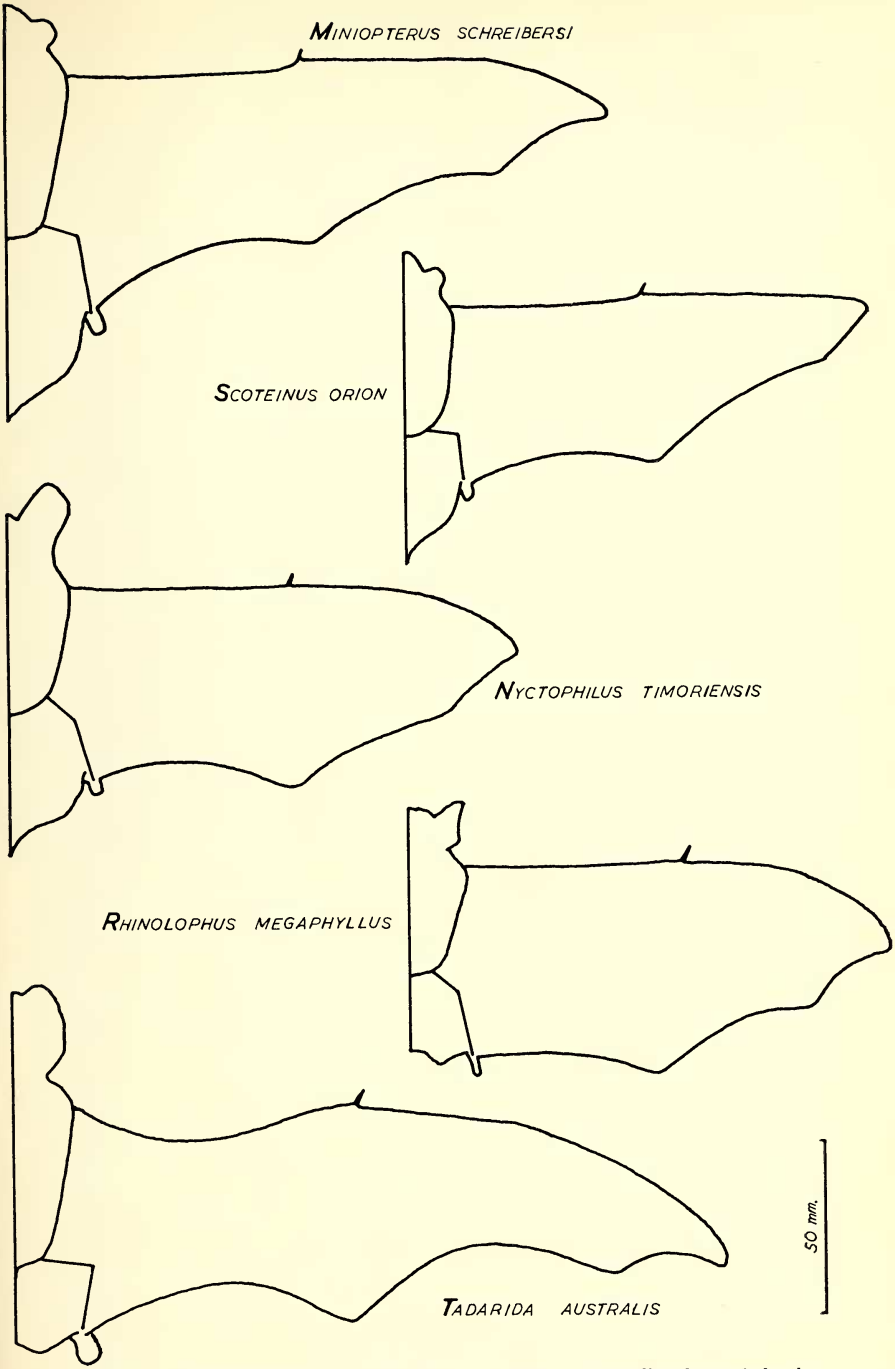

Fig. 1. Outlines of flight membranes for five eastern Australian bats. Only the right hand side is drawn.

Results

Values obtained for the selected morphological criteria are given, for 17 species, in Table 1. Wing outlines for selected species are shown in Fig. 1 to illustrate the most striking differences observed. The 17 species can be placed in eight groups on the basis of expected flight patterns deduced from the table.

(1) *Pteropus scapulatus* (Fam. Pteropidae) stands apart from all others in having extremely high values for loading and for the ratio wing area/uropatagial area. Moderate speed and very little manoeuverability would be expected. The well known helplessness of "flying foxes" on the ground, and their crash-landings in trees, correlate well with high loading. Flight of these bats is direct and at moderate speed.

(2) *Rhinolophus megaphyllus* (Fam. Rhinolophidae) has a very high wing/uropatagial ratio, but the limiting effects of this upon manoeuverability could be countered by the combination of moderately low wing loading and very low aspect ratio. Frequent field observations of this species have established that it regularly flies low, within a few feet of the ground, and is able to manoeuvre successfully amongst the branches and foliage of dense shrub areas. It may also ascend into the canopy of larger trees. Speed is slow and flight appears fluttery. The ability to hover has often been noted. Harrison-Matthews (1952) describes low and fluttery flight for *R. hipposideros* and *R. ferrumequinum* in Britain, and the habit of this latter species of frequently taking prey to a roost for eating is shared by *R. megaphyllus* in New South Wales. Insect wings dropped below feeding stations

TABLE 1—Flight Characteristics of Some Australian Bats.

Species	Number examined	Area wing / Area uro.	Aspect Ratio Without uro.	Aspect Ratio With uro.	Load Uro.	Load Wing.
Pteropus scapulatus	1	43·1	8·2	8·0	33·2	0·77
Rhinolophus megaphyllus	2	17·2	6·7	6·4	3·1	0·18
Tadarida australis	1	15·6	12·4	11·6	7·4	0·48
**Taphozous flaviventris*	1	12·1	9·7	9·0	4·4	0·36
Scoteinus orion	1	9·7	8·3	7·6	2·8	0·28
Scoteinus rueppelli	1	9·4	8·1	7·3	3·1	0·33
Chalinolobus sp.	2	8·7	7·8	7·0	1·4	0·17
Nyctophilus timoriensis	3	8·5	7·2	6·5	1·5	0·17
Nyctophilus geoffroyi	5	8·2	7·5	6·5	1·5	0·17
**Scoteinus greyi*	1	7·9	7·6	6·7	1·6	0·15
**Myotis adversus*	2	8·8	8·4	7·5	1·7	0·19
Miniopterus australis	3	8·2	8·4	7·5	1·3	0·16
**Pipistrellus tasmaniensis*	1	7·7	10·1	8·9	2·3	0·30
Miniopterus schreibersi	3	7·4	9·5	8·3	2·0	0·27
Eptesicus pumilus	1	7·1	9·1	8·0	1·5	0·19
Chalinolobus gouldi	4	7·1	8·7	7·6	1·7	0·22
**Chalinolobus morio*	1	6·2	8·3	7·2	0·9	0·14

Weights used to calculate loading are live weights except where the species is marked with an asterisk. For these latter the weight used was taken as 80% of preserved weight, this figure being derived from 10 bats, of known live weight, which were preserved similarly. Where more than one individual of a species was measured the figures given are averages. Vertical spacing is used to separate the 8 flight groups discussed.

suggest that large, and relatively ponderous, insects are important in the diet.

(3) *Tadarida australis* (Fam. Molossidae) and *Taphozous flaviventris* (Emballonuridae) are characterized by a combination of small uropatagium, high aspect ratio, and high wing loading. *T. australis,* in particular, should stand apart as a fast-flying, relatively unmanoeuverable, bat that is probably capable of sustained flight for considerable periods. Van Deusen and Petersen (1958) have noted the swift direct flight of *Tadarida* in Australia and Vaughan (1959) has referred to similar characteristics in another molossid species. Some molossids cannot fly from the ground but *T. australis* is able to launch itself, with some difficulty, from rough horizontal surfaces. A captive individual could not maintain flight in a room 25 x 15 ft. *T. flaviventris* shows considerably less extreme values than *T. australis* for aspect ratio and loading. Slower and more manoeuverable flight could be expected.

The other species examined (species of the family Vespertilionidae) do not show the extremes of aspect ratio or the very high values for loading indicated above. In comparison with other families, the vespertilionids have well developed uropatagia (i.e. high values for wing area/uropatagial area) and reduced loading. The 13 species considered can, however, be classed in five groups.

(4) *Scoteinus rueppelli* and *Scoteinus orion* (Sub-fam. Vespertilioninae) have relatively small uropatagial membranes, quite high wing loading, and intermediate aspect ratio. Flight would be expected to be at moderate speed and to show little manoeuverability. Calaby (pers. comm.) has observed such characteristics for *S. rueppelli* and described this species as flying repeatedly up and down a line of trees at about 30-60 ft. Identification was established by shooting specimens in flight. I have observed similar behaviour, in which only slight deviations were made from the flight path to chase insects, but without identification of the bat. Relatively large (1 inch), and slow flying beetles are known to form part of the diet of these *Scoteinus* species.

(5) *Scoteinus greyi* and *Chalinolobus* sp.* (Sub-fam. Vespertilioninae), and the two species of *Nyctophilus* (Sub-fam. Nyctophilinae) have only moderately large uropatagial membranes relative to wing area, but may obtain extremely high manoeuverability by combining low loading with low aspect ratio. *N. geoffroyi* is apparently the commonest town bat of the Northern Tablelands (N.S.W.) It forages by flying at about 20-30 ft. and dropping vertically upon insects. The "drops" are extremely rapid and may be to within inches of the ground. After each drop the bat then resumes, approximately, its former height. Relatively small feeding areas seem to be established, and to be revisited on successive nights, and within these flight is haphazard. Dew (pers. comm.) has observed *N. geoffroyi* alight on the ground to capture insects, while McKean and Hall (1964) record the habit of taking food (moths and beetles) to a roost for eating.

Chalinolobus sp., when liberated outside their roost, flew relatively slowly, with little amplitude to the wing beat, and with considerable manoeuverability. Flight was not very erratic. The bats characteristically flew at about mid-canopy level some 20-30 ft. above the ground.

* This species of *Chalinolobus* from the Northwestern Slopes of New South Wales is closely related to *C. picatus* (Ryan, pers. comm.).

(6) *Myotis adversus* (Sub-fam. Vespertilioninae) and *Miniopterus australis* (Sub-fam. Miniopterinae) are treated as a separate group for they have aspect ratios and loading intermediate between the bats of groups 5 and 7. Such separation thereby gives emphasis to the differences between these groups. *M. australis* usually flies quite rapidly and with considerable manoeuverability, between shrub and canopy layers of densely wooded areas. *M. adversus* has the smaller uropatagium and greater loading and could be expected to be less manoeuverable.

(7) *Eptesicus pumilus, Chalinolobus gouldi,* and *Pipistrellus tasmaniensis* (Sub-fam. Vespertilioninae), and *Miniopterus schreibersi* (Sub-fam. Miniopterinae) have relatively high aspect ratios and intermediate wing loading. The low values for wing area/uropatagial area suggest that manoeuverability in these species is primarily the concern of the uropatagium. In forested areas *M. schreibersi* flies high, from just above the canopy to many times canopy height, but in more open areas such as grasslands flight may be within 20 ft. of the ground. Flight is very fast and typically relatively level and swift shallow dives, rather than erratic tumbling, are the rule. In addition, however, flight can be extremely erratic within the same horizontal plane much after the fashion of snipe (*Gallinago* spp.) and these deviations are presumably to catch insect food. Nothing is known about the diet of this bat other than it is predominantly lepidopterous in content, for moth remnants are extremely abundant in guano deposits. It is considered possible that some of the high flying hepialids and noctuids may be of importance. The extensive accumulations of moth wings reported from the Lake Gillear Guano Cave (Warrnambool, Vict.) by McKean and Hall (1964) suggest that they must have been dropped by *M. schreibersi* returning with food to the roost for no other bats are known from this cave. My observations show that these wings (noctuids) are well distributed through the cave but are especially concentrated at a few points in the large entrance chamber. If they are indeed the work of *M. schreibersi* the record is remarkable for nothing similar has been noted elsewhere in the south-eastern Australian range, and I am satisfied for north-eastern New South Wales that food is consumed away from the roosts. Overnight recoveries of several marked females of this species have demonstrated that distances up to 40 miles may be covered in a single night. Constant and Cannonge (1957) have estimated flight speeds of 31 m.p.h. for *M. schreibersi* used in homing experiments.

C. gouldi is considerably slower than *M. schreibersi* and appears to forage below canopy level in relatively open woodland areas. Flight of *E. pumilus* is characterized by moderate speed, manoeuverability, and by frequent landings in foliage. The bats characteristically fly within woodland areas, from about 5 ft. to near canopy level. Flight path is typically well clear of foliage and it is possible that observed landings were for eating, rather than hunting, purposes. *P. tasmaniensis* has the smallest uropatagium and highest wing loading of this group of bats and should, therefore, be the least manoeuverable.

(8) *Chalinolobus morio* (Sub-fam. Vespertilioninae) is considered on its own. Intermediate values for aspect ratio are combined with low loading and a very large uropatagium. The development of the tail membrane includes even the postcalcaneal lobes

which are especially enlarged in this species. Moderate speeds and considerable manoeuverability were observed when a captive individual flew in a small room. These observations support aerodynamic expectation.

Discussion

The correlation between expected flight characteristics, based on aerodynamic properties, and observed patterns is striking for *M. schreibersi, N. geoffroyi,* and *S. rueppelli,* and applies to a lesser extent for *R. megaphyllus* and *E. pumilus.* It is probable, therefore, that characteristics deduced for other species are meaningful and it follows that a wide range of flight patterns has been shown to exist amongst south-eastern Australian Microchiroptera. The most striking differences in behaviour tend to reflect family divisions. Thus, *R. megaphyllus* has apparently achieved great manoeuverability by reduction of aspect ratio whereas in the verspertilionids manoeuverability results primarily from increase in uropatagial area and decrease in loading. The conspicuous separation of the three species of *Chalinolobus* on the basis of flight characteristics is noteworthy, for these species are not obviously separated in terms of spatial or habitat distribution.

It is certain that specific flight patterns reflect specific feeding habits and that future work is required to refine the generalization that these bats are "insectivorous".

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Notes on Two Eucalypts from Arnhem Land

By E. Colline Muir

Following Miss Jean Galbraith's interesting article on *Eucalyptus miniata* (*Vict. Nat.* Feb. 1965) perhaps one or two general observations may be of interest.

Where I saw it in Southern Arnhem Land, *E. miniata* was a handsome and beautiful tree, which grew on the dissected sandstone plateau country. It shared this habitat with a closely allied and, in that area, much more common tree, *E. phoenicea,* these two species comprising the series *Miniatae.*

Eucalyptus phoenicea was, in this area, the smaller of the two, and seldom grew upright, preferring to arch its trunk and send up more vertical branches from it, the whole forming a rounded crown, while *E. miniata* grew very straight, up to fifty feet or more, with a girth of perhaps two and a half feet or more at the base. Miss Galbraith tells me that the specimens collected by Miss Walker near Darwin came from a tree that was low and shrubby. Both species have a curious fibrous-scaly bark, often with a decided "crimp", and contain straight, hard fibres that pierce the skin, and may be found in all parts